Material Efficiency & Resource Conservation

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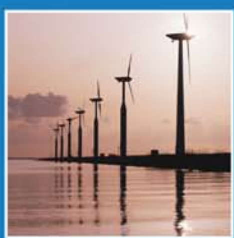
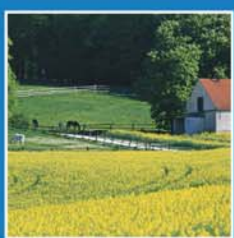
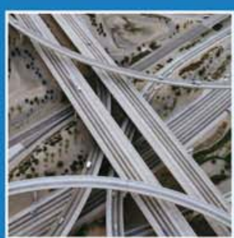
Identification of technologies, products and strategies with high resource efficiency potential – results of a cooperative selection process

Milestone report from Task 1 of the MaRess project

Translation by Ute Wellenberg (Trifolium - Beratungsgesellschaft mbH)

ResourceEfficiency Paper 1.3

Wuppertal, September 2009
ISSN 1867-0237

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"Material Efficiency and Resource Conservation"
(MaRess) – Project on behalf of BMU I UBA

Project Duration: 07/2007 – 12/2010

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The project is funded within the framework of the UFOPLAN
by BMU and UBA, FKZ: 3707 93 300

The authors are responsible for the content of the paper.

Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety

Umwelt
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1 Introduction

The pressure on the environment caused by resource use and the related emissions as well as waste disposal lead to ecological but also economical and social problems. Insecurities in supply, shortages of resources and related international raw material conflicts, high and strongly fluctuating raw material prices can lead to massive economical and social problems around the world. Disadvantages for competition arise from the inefficient use of resources, thus endangering the development of jobs and companies. Therefore, the increase of resource efficiency is becoming a political top issue. Facing this development, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Environment Agency (UBA) entrusted 31 project partners with the research project “material efficiency and resource conservation” (MaRess, see also http://ressourcen.wupperinst.org). The project is coordinated and managed by the Wuppertal Institute for Climate, Environment and Energy.

The MaRess project aims at making substantial steps in the following issues concerning resource efficiency and conservation:

- The potentials of the increase of resource efficiency are determined.
- The initial stages of target-group specific resource efficiency policies are developed.
- The analysis of the effects of an increasing resource efficiency on macro- and micro-economic level.
- Agenda-setting, dissemination and implementation of resource efficiency on the basis of the scientific results.

Focus and aim of this paper

This paper deals with the evaluation of potentials for an increase in resource efficiency. A summary of existing knowledge and resource efficiency is given. The paper presents the state of work and the **interim results** of Task 1 (“Identification of innovative lead products, lead technologies and lead markets increasing resource efficiency”) of the MaRess-project after the finalisation of the first Task (AS1.1) of the Task 1.

Task 1 identifies products and technologies with high resource efficiency potential (lead products and technologies) and markets for resource efficient products (lead markets). In a next step, appr. 20 selected lead technologies and products will be evaluated in depth. The link to innovative services is respected as they facilitate the establishment of lead markets.

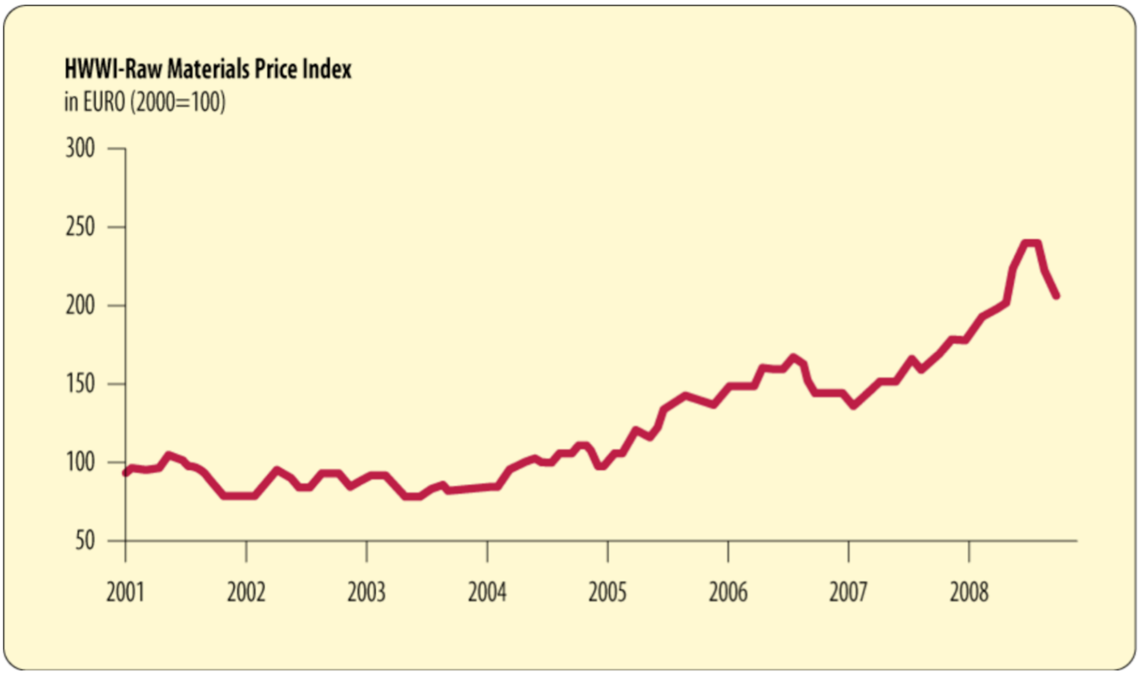
2 The basis: resource efficiency

This section describes the basis for the research in Task 1 of the MaRess project (see section 3). Special attention will be paid to the state of knowledge concerning focus industries, demand areas and relevant markets for resource efficiency. Key findings from existing studies are presented. According to them, there is already a broad knowledge concerning resource efficiency but actual potentials of products and technologies have not been determined. The quantitative estimates existing so far are in most cases not consistently documented or deal with macro-level contexts not going into the details of actual implementation (also see section 3.1).

2.1 Relevance of the resource efficiency

Due to increasing prices and price fluctuations on the worldwide energy and raw material markets (see Fig. 1), the sustainable management of natural resources has become more and more important. This is underlined by an intensive debate on an effective resource efficiency policy (see e.g. BMU 2006). A policy paper of the MaRess project (Kristof / Hennicke 2008) presents five key strategies in order to give a sustainable direction to innovation and economical modernisation.

Fig. 1: HWWI-index of the prices for raw materials 2001-2008

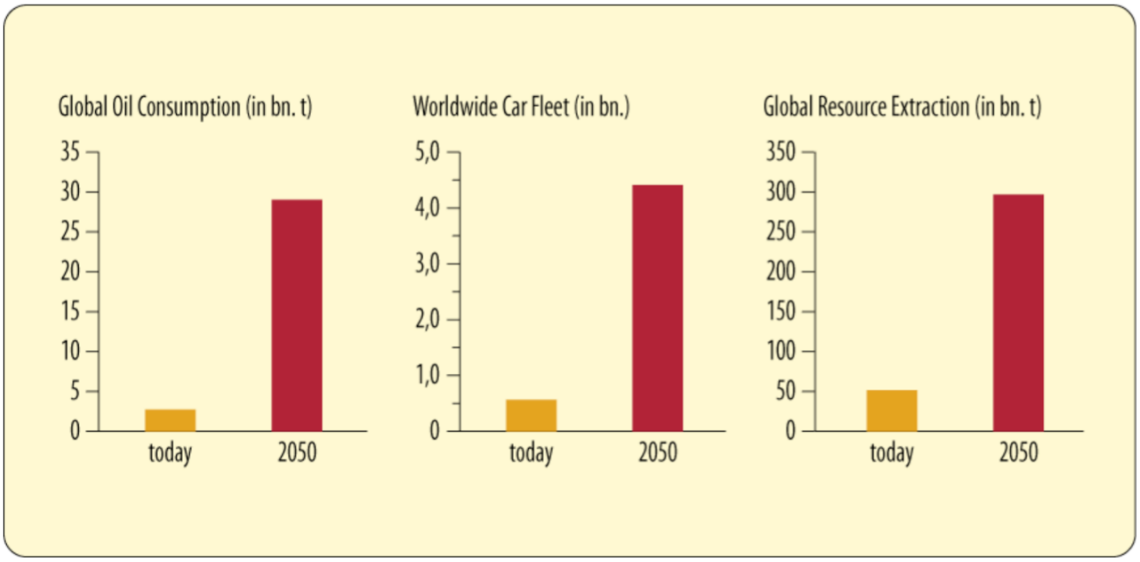


Source: HWWA 2008

The global consumption of materials, especially of industrial raw materials like crude oil, hard coal, steel, aluminium or copper, has strongly increased over the past 30 years. The process of industrialisation in emerging markets accelerates this process. The world economy is expected to grow by three percent each year until 2030 (see BMU 2007).

Also the growth of the world population increases demand. Until 2050 over 9 billion men will live on earth and an increasing number will live in cities and/or industrial societies (see BMU 2007). Fig. 2 shows the estimated worldwide requirement for raw materials and products in 2050 if the present development is continuing.

Fig. 2: Worldwide need for raw materials in 2050 without additional increase in efficiency



Source: Hennicke 2006 (own calculations)

2.2 Resource intensive industries

A research by the Wuppertal Institute shows that in 1991 and 2000 approx. 75% of the production-related TMR (Total Material Requirement, the total direct and indirect material use of a national economy) in Germany can be linked to the twelve sectors mentioned separately in Tab. 1. These represent the most resource intensive activities in Germany (see Acosta-Fernández 2007):

Tab. 1: Direct and indirect use of resources in Germany induced by sectoral national production for end-use

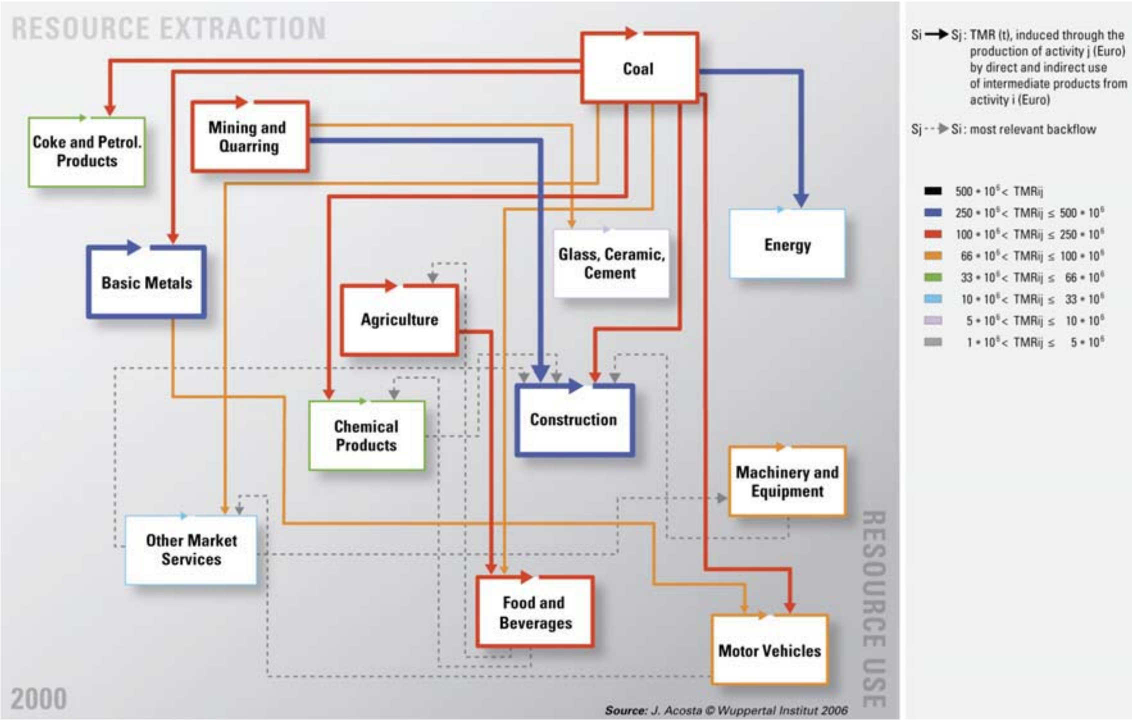
NACE Rev.1 sect.[1]	Production sector	Direct & indirect use of resources in 2000	
		million tonnes	%
45	Construction	964	18
15	Manufacture of food products and beverages	465	9
27	Manufacture of basic metals	459	9
40	Electricity, gas, steam and hot water supply	405	8
34	Manufacture of motor vehicles, trailers and semi-trailers	335	6
24	Manufacture of chemicals and chemical products	269	5
29	Manufacture of machinery and equipment n.e.c.	211	4
10	Mining of coal and lignite; extraction of peat	188	4
1	Agriculture, hunting and related service activities	183	3
23	Manufacture of coke, refined petroleum products and nuclear fuel	157	3
26	Manufacture of other non-metallic mineral products	157	3
14	Other mining and quarrying	136	3
	Other production sectors	1.360	26
	All production sectors in sum	**5.843**	**100**

Source: Acosta-Fernández 2007

Number one is the construction sector. It represented 18% of the TMR of the production-related resource consumption for end-use. Also the sectors “food industry”, “automotive industry”, “metals” and “energy” showed high values with around 5% each. The resource consumption by end-production of all service sectors measures around 15% of TMR (see also Kristof 2007).

The multiple links within the value chains and sectors are interdependent with a complex product-service-exchange between resource intensive sectors (see Fig. 3).

Fig. 3: Interdependence of production sectors in Germany 2000



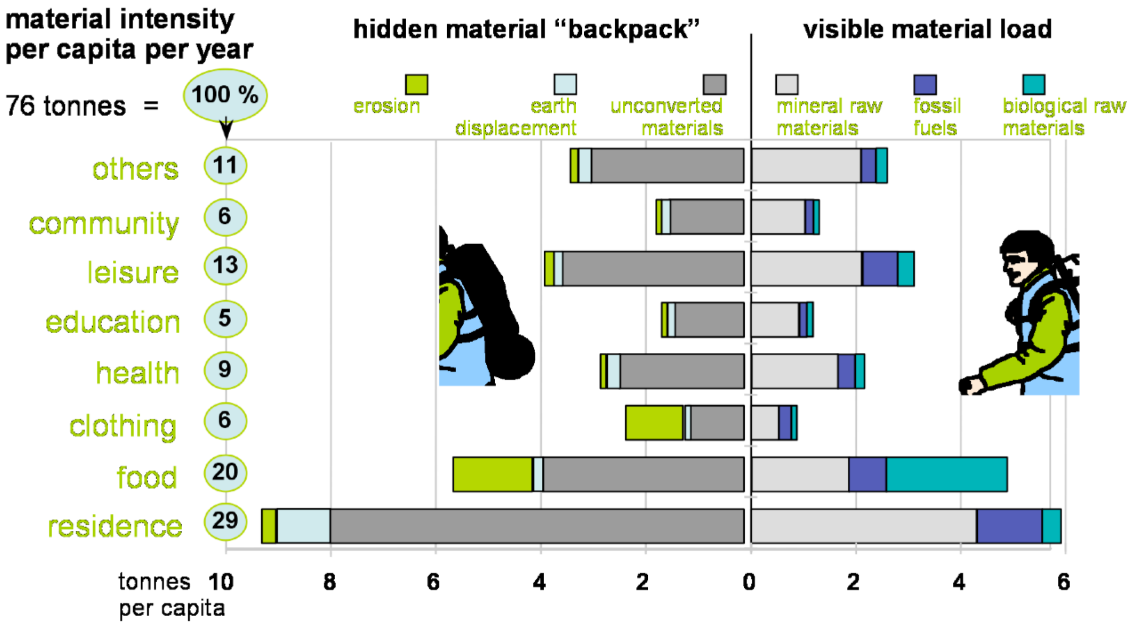
Source: Acosta-Fernández 2007

2.3 Resource intensive fields of demand

The examination of the resource consumption by areas of demand (see Fig. 4) is based on macro-economic data of material flows. It reveals that half of the resource consumption arises from the areas “housing” and “nutrition”. This concerns the direct and indirect resource consumption equally. Other important demand areas are “leisure” and “health” (see Matthews et al. 2000; Bringezu / Schütz 2001). Mobility is integrated into each demand area (e.g. driving to the supermarket into “nutrition”) and is therefore not mentioned especially. The area of “housing” includes buildings as well as thermal energy consumption.

[1] NACE Rev.1 sect. (Nomenclature statistique des activités économiques dans la Communauté européenne) is a system for the classification of branches. The existing 60 departments can be identified through a two-digit numerical code.

Fig. 4: Distribution of the direct and indirect resource consumption into areas of needs



Source: Mathews et al. 2000; Bringezu / Schütz 2001

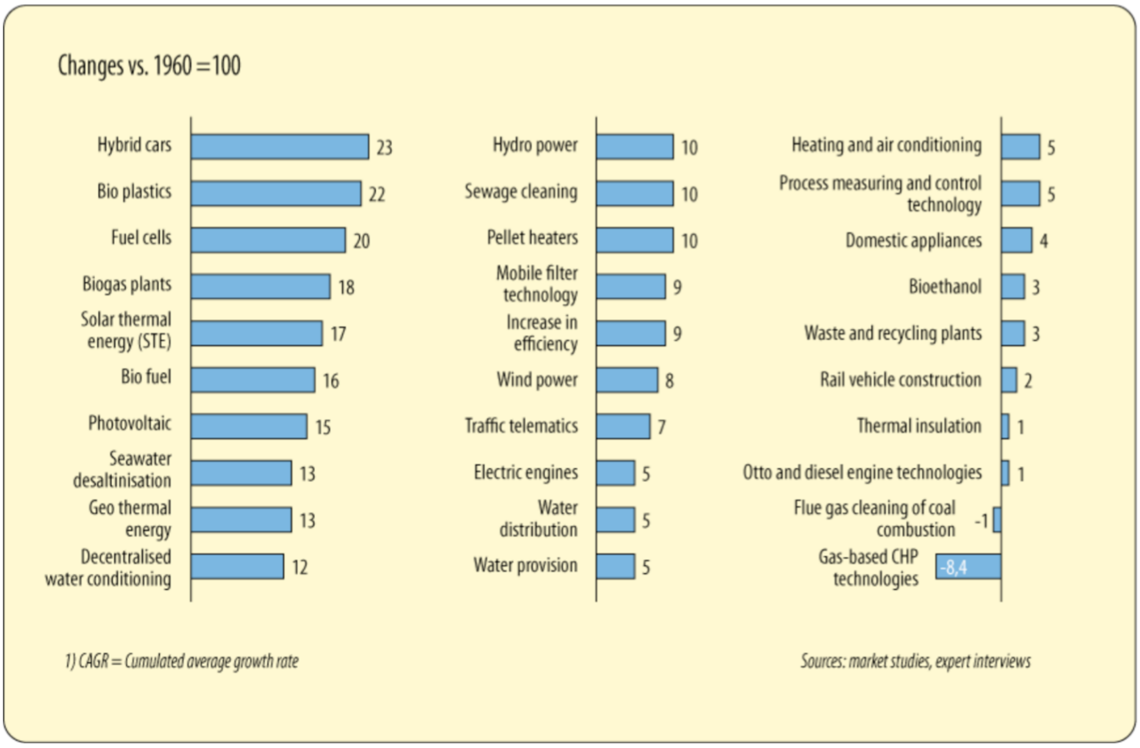
A new research on the micro-level about the total resource consumption of 27 Finnish households (Kotakorpi / Lähteenoja / Lettenmeier 2008) identifies the consumption areas "mobility", "tourism", "housing" and "nutrition" as most relevant. In this study, mobility includes all trips of the households (except for tourism) and housing includes the total electricity consumption (e.g. also for cooking). The study reveals differences up to a factor of 10 within the total resource consumption of the different households. Especially significant differences were found in the fields of mobility, leisure and tourism. They are due to different consumption patterns and lifestyles of the households.

Both studies show that housing and nutrition as real fields of demand have the highest relevance for resource consumption. In addition, mobility is very important, regardless of whether it is classed to single fields of demand or not. Within the fields of housing and mobility the existing infrastructure is of special relevance in terms for resource consumption.

2.4 Markets for resource efficiency

A study by Roland Berger Consultants points out that environmental technologies show high market potential and a dynamic growth around the globe (see BMU 2007). The six leading markets identified in this study (environmentally sound energy production and storage, energy efficiency, material efficiency, recycling, sustainable fittings and furnishings, sustainable water management) yet represented a total volume of 1,000 billion Euros in 2005. Out of these, the market for material efficiency has the highest annual growth rate expected, 8 %. Regarding the growth expectations of single technologies, hybrid vehicles, bioplastics and fuel cells have the highest market potentials (see Fig. 5). Twelve technologies out of these have been selected and examined in depth in individual studies (Zukunftsmarktstudien, download under www.umweltbundesamt.de). These studies estimated only market but no resource efficiency potentials.

Fig. 5: Predicted annual growth rates of environmental technologies in percent 2005-2020



Source: BMU 2007

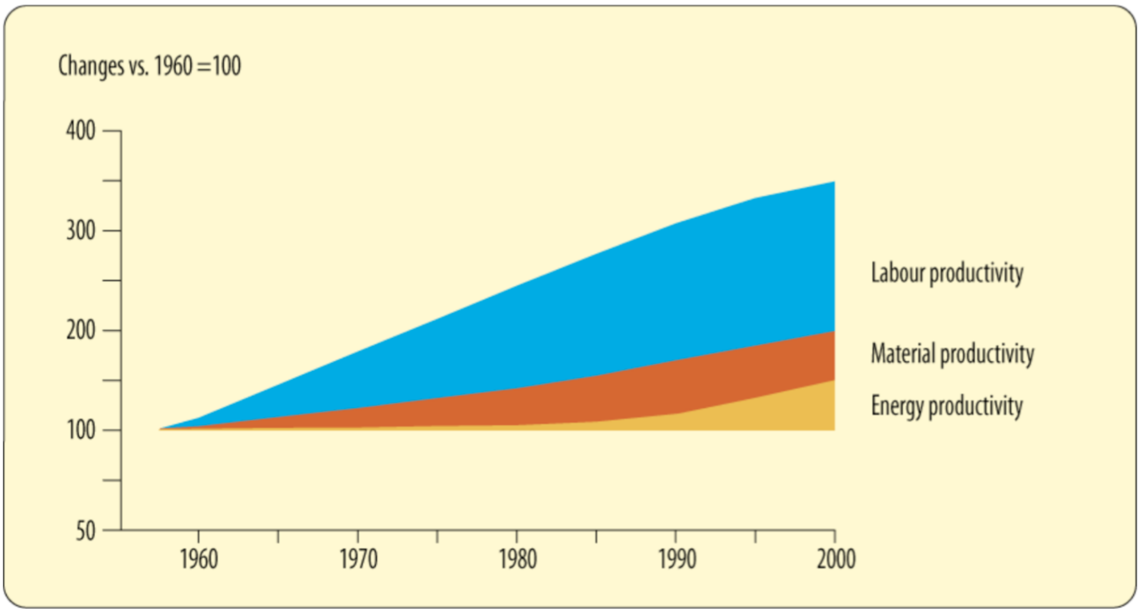
In addition to these, a comprehensive study has been carried out within Task 1 of the MaRess project on market potentials in the BRIC countries, i.e. Brasil, Russia, India and China (see Petruschke 2009). The first results show that a dynamic economic growth forms the socio-economic background of new consumption patterns and the corresponding resource consumption. The economic growth influences in particular the development of a new middle-class with new preferences and needs. This leads to a extraordinary increase in demand for private consumption goods.

According to the study, the increasing globalisation of work, material use and financial capital tend to cause an assimilation of cultural habits and therefore also an assimilation of demand preferences. In general, it showed that, as already discussed in a European context, within economical development processes the areas of mobility, nutrition, agriculture, construction and housing gain importance. In the field of nutrition the increasing demand for meat and milk products as well as for processed foods was stressed in the BRIC context. In the field of housing the increasing demand for household goods and furniture as well as an increase in living space per capita were identified as priorities. In the field of mobility the increasing demand for personal mobility and thus also for traffic infrastructure was underlined.

2.5 Relevance of resource efficiency for companies

In average, 40% of the gross production costs in the German manufacturing sector are material costs. Thus, they represent the biggest part of all costs before personnel costs with around 25%, energy costs with approximately 2% and others. Consequently, a reduction of the material consumption promises major cost saving potentials (see ADL / Wuppertal Institute / ISI 2005). This important wheel has not yet been sufficiently set into motion in order to improve material efficiency (see Fig. 6) although significant cost saving potentials could be realised (see Tab. 2).

Fig. 6: Development of productivity in the manufacturing sector



Source: Statistisches Bundesamt 2002

Tab. 2: First estimations of the material efficiency potentials in selected industries

Industry	Material input in bn. € in 2002	Material saving potential in bn. € p.a.
Manufacturing of metals products	18,6	0,8–1,5
Manufacturing of plastics	10,8	1,0–2,0
Manufacturing of devices for electricity production and distribution	10,2	1,5–3,0
Chemicals without primary chemicals	11,1	1,8–3,4
Construction: structural engineering and conversion	11,1	0,2–1,2
Total potential (autonomic and induced)	**61,8**	**5,3–11,1**

Source: ADL / Wuppertal Institut / ISI 2005

In general, a higher resource efficiency can have the following benefits (see e.g. Ritthoff et al. 2007, Bringezu 2004, Van der Voet et al. 2005, Schmidt-Bleek 2004, Liedtke / Busch 2005):

- Cost reduction through smaller resource consumption, incl. less expensive products and smaller costs during the use phase,
- Increase of raw material security,
- Decrease of emissions and waste during the entire lifecycle.

Furthermore, it enables innovation within the product and production area and therefore the opening-up of new markets for products with smaller resource input. Here, national markets as well as international export markets can be addressed.

For companies there are the following initial points for the increase of resource efficiency (see Ritthoff et al. 2007):

- Reduction of resource losses through improving product quality (decrease in rejects),
- Optimisation of production processes, e.g. through the reduction of cutting losses,
- Optimisation of product structure, resource efficient product design (e.g. lightweight construction, lighter products),
- Increased recycling of production material,
- Better usage of machine capacities,
- Holistic value chain optimisations across organisations.

Cost saving potentials of even 10 % and more are possible through such optimisation measures (Baron et al. 2005; Bundesministerium 2007).

But one should not only pay attention to single processes. In an integrated optimisation all upstream and downstream processes from raw materials mining up to disposal should be regarded. This is a major challenge because the complex and globalised value chains make it difficult to track and influence all primary products.

In practice, different obstacles prevent the examination of such potentials (see ADL / Wuppertal Institut / ISI 2005):

1) There is only insufficient knowledge about new materials and processes able to provide higher resource efficiency.
2) There is a risk perception for switching to new, material efficient production processes.
3) Resource efficiency gains should be achieved over the entire value chains but this demands a new kind of intense cooperation of multiple actors involved.

In order to release the advantages of resource efficiency described above, there are numerous initiatives in Germany that mainly address small and medium sized companies (SMEs). Subsidy und impulse programs and networks are organised on state as well as on federal level . For instance there are agencies simultanously consulting and funding, like the Efficiency Agency North-Rhine Westphalia (EFA) and the German material efficiency agency (demea). Support and possibilities for participation are offered by the PIUS-network (see www.pius-info.de) or the network for resource efficiency (see http://www.netzwerk-ressourceneffizienz.de).

2.6 Eco-innovation: resource efficient products, processes, technologies and services

An important initial step for increasing the resource efficiency on a company level is the ability for innovation. “Eco-Innovation means the creation of novel and competitively priced goods, processes, systems, services, and procedures that can satisfy human needs and bring quality of life to all people with a life-cycle-wide minimal use of natural resources (material including energy carriers, and surface area) per unit output, and a minimal release of toxic substances.” (see Reid / Miedzinski 2008).

Eco-innovation includes new or improved solutions with the aim of increasing the resource efficiency or reducing the environmental impacts. When implementing eco-innovation all causal connections within a systemic context should be considered (see Reid / Miedzinski 2008). This includes the raw materials required, the technology the product is based on, the functionalities and the use of the product (consumption good, service, hybrid product, strategies for efficient use, decomposition etc.).

Especially in an early stage of the product innovation process (generation of ideas, design, R&D) central decision are made that influence the future resource efficiency of the product. This opens manifold options for the sustainable and environmentally sound design of processes, products and services.

In this context, technologies and their applications as well as products and strategies, that may increase the resource efficiency, play and important role (see Neugebauer et al. 2008 / Bullinger et al. 2000 / Spath 2003). They can facilitate new products, processes and services but also crucial organisational innovations, that lead to saving resources.

In this context, technologies can be utilised in the following ways:

- New resource efficiency technologies replace existing technologies or the state-of-the-art in an existing application field in order to increase resource efficiency (competing technology / substitute technology).
- Innovative functionalities of new technologies lead to new applications resulting in a higher resource efficiency (new technology field).

In addition to the theoretical possibilities of new technologies, one should also consider their potential applications in practice. These are connected with different boundary conditions. For instance there are technical, regulatory and market requirements for design, prices and authorisations or approvals.

3 Resource efficiency potentials by technologies, products and strategies

Based on the observations above, this section will first present knowledge gaps and the expected knowledge increase from Task 1 of the MaRess project. After that, the procedure for the selection of resource efficient technologies, products and strategies will be introduced. This includes the criteria for the selection as well as the structuring of the research field. The presentation of the results obtained so far will be differentiated according to the working steps performed: the analysis, the pre-selection and the criteria-based evaluation.

3.1 Gaps and expected increase in knowledge through Task 1

While there is a general acceptance for the need of a higher resource efficiency on the macro-level (e.g. Factor 4, Factor 10), no broad and yet specific examination has been carried out so far on the quantitative potentials existing nor on how to implement them. The existing studies, publications and expertises for the potentials for resource efficiency remain often on an abstract and unspecific level, usually without a possibility for the estimation of rebound effects. There are plenty of project-based single studies but they usually are lacking of the analysis of general national economic resource efficiency potentials.

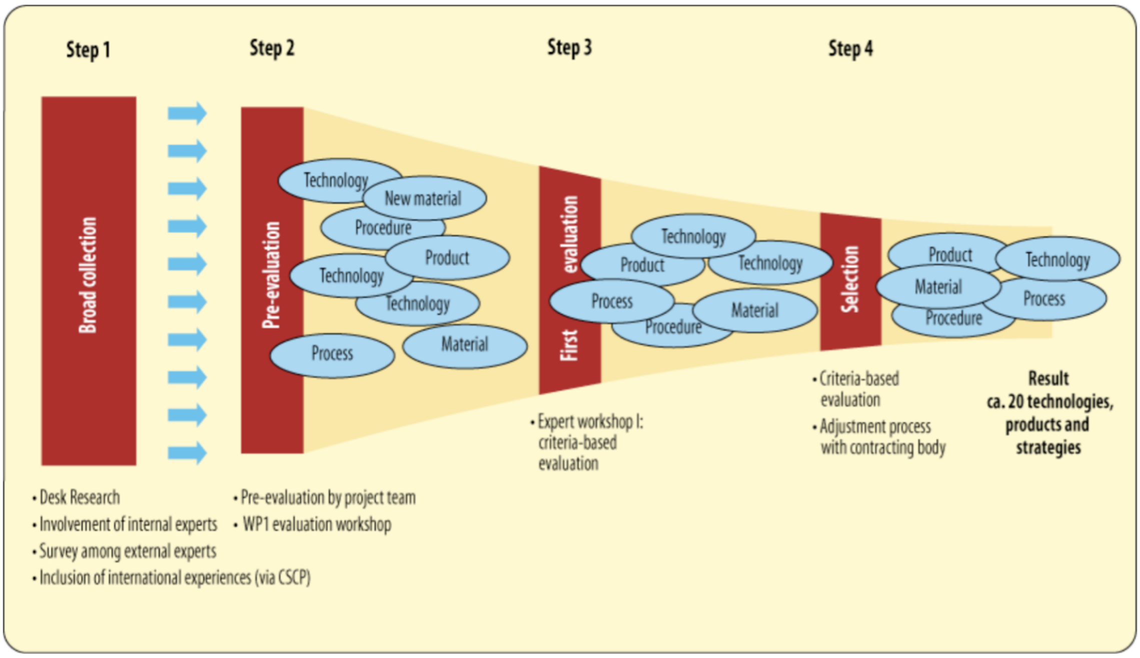
The Task 1 aims at identifying lead products and technologies with high resource efficiency potentials and at quantifying the resource efficiency potentials of 20 especially relevant technologies, products and strategies. The results will be documented transparently and uniformly and put into a national economy perspective. Besides that, Task 1 offers a summary of the current state of relevant estimations for resource efficiency. Thus, it provides the possibility of summing up and enlarging the discussion of the resource efficiency of distinct industries and areas of needs. The bundled research of 20 topics of resource efficiency provides an impetus concerning methods and data in this field.

Furthermore, the accomplishment of a thesis programme for the examination of resource efficiency potentials, embedded in an expert network, shall diffuse the topic in academic education and build up a network between universities. Moreover, there is a perspective for intensifying the topic in the academic education of future decision-makers. Further, it is possible to use the results of Task 1 within other Tasks of the MaRess project as well as in future projects developing, e.g., instruments, communication strategies and roadmaps.

3.2 Procedure of the selection

The basic procedure for the selection of technologies, products and strategies increasing resource efficiency consists of four steps (see Fig. 7):

Fig. 7: Criteria-based selection of technologies, products and strategies with high resource efficiency potential



Source: Own Figure

In a first step, technologies, products and strategies increasing resource efficiency were identified by desk research and a survey. Then, they were structured and put into an overview list (topic list with about 1000 proposals). This list was the basis for the further selection process. In the desk research, relevant studies, publications and data and knowledge collections were identified and evaluated[2]. A focus was put on studies providing a logical and structured presentation and examination of relevant technologies and products. The ones that had been mentioned most frequently or that had the highest potentials according to expert opinions were included in the research. A structuring of the field will be presented in section 3.3.

The survey conducted had the aim of enriching and broadening the overview from the desk research with further products and technologies. The survey was primarily addressed to experts from university and non-university research institutes and organisations but also to associations, initiatives and companies. Due to the participation of the Task 1 partners, the survey was sent to appr. 15,000 experts – a relatively large amount. The experts were contacted directly per e-mail and by various mailing lists. The survey had been attached to the e-mails and was open for download on the project homepage. Besides that, the survey had been promoted in relevant newsletters to inform other stakeholders. The experts were asked to complete the questionnaire. In addition to enriching the collection of technologies, products and strategies increasing

[2] The research is mainly based on German speaking sources. There are a few exceptions. In total, over 100 sources have been evaluated.

resource efficiency, the survey served as PR for the MaRess project, as a sensitising instrument for of the issue of resource efficiency and for the acquisition of new persons and institutions to become involved in the resource efficiency network.

In the second step, a first analysis and pre-evaluation of the topic list took place. The pre-evaluation consisted of a general evaluation according to three criteria: resource input, resource efficiency potential and economic relevance (see Tab 3). The result was a pre-evaluated topic list with around 250 nominations ("Top250").

The third step was the criteria-based expert-evaluation. On this basis, a ranking was performed for the "Top250" sorted by topics. In the course of a workshop with the Task 1 - partners and additional experts, this ranking was discussed, revised and validated. On this basis, a revised topic list with around 50 proposals ("Top50") was deduced (see section 3.4).

The evaluation of the "Top250" topic list by experts was done according to seven criteria. It was a qualitative evaluation based on quantifiable data as far as possible. (An analysis of the resource efficiency potential including detailed quantifications takes places in the further course of the project for the selected "Top20" topics.) The criteria (see Tab 3) served for a rough pre-selection of especially resource efficient, resource relevant and innovative but also new and visionary technologies, products and strategies. The focus of the criteria on resource efficiency was completed by criteria that are significant for the implementation. Exemplary aspects explaining the criteria were added to each of them in order to facilitate the evaluation. Not all of the explanatory aspects of a criteria need to be relevant simultaneously.

The criteria-based selection was performed out of the especially relevant fields and the single topics included in these fields (see section 3.4.2). For this selection, the criteria were weighed with factors for importance and the results evaluated by comparing different results. 20 topics were prioritised for further examination.

On this basis, the final selection of the "Top20" products, technologies and strategies was performed in cooperation with the Federal Environment Agency (UBA) and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). A detailed potential analysis will be conducted in the further course of the project for all topics of the final topic list ("Top20"). This selection was based on the priorities set by the Task 1 - partners and experts of the expert workshop and on the criteria mentioned (see Tab. 3).

Thus, the decision for the "Top20" was based on the whole procedure explained in this section. The topics are listed in section 3.5.

Tab. 3: Criteria for the evaluation of technologies, products and strategies

Nr.	Criteria for the evaluation of technologies, products and strategies
1	**Resource input in terms of mass relevance**, e. g.: • Unit of production or infrastructure with high resource input (absolute high input, e.g. steel mill) • Mass application (e.g. pumps) • Possible rebound effects
2	**Resource efficiency potential** regarding, e.g.: • Abiotic resources • Biotic resources • Water • Energy • Other
3	**Other environmental impacts**, e. g.: • Health risks • Global warming potential • Emission in water, soil and/or air • Acidification • Eutrophication • Surface consumption • Erosion • Biodiversity
4	**Feasibility**, e. g.: • Technical feasibility • Profitability • Technological competence in Germany • Acceptance (market, society)
5	**Economic relevance**, e.g.: • Market potential • Innovation degree • Relevance for export • International relevance • Social trends (e.g. demography) • Dependence on non-renewable natural resources
6	**Relevance for communication**, e.g.: • Effect as publicity • Promising fast successes • Easy to understand
7	**Transferability**, e.g.: • Transferability to other fields of activity • International transferability

Source: Own Figure

3.3 Structuring the field of research

This section explains the reflections, on the basis of which the field of research was structured into technologies, products and strategies. The structuring is based on different overview studies and pays special attention to areas that promise high resource efficiency potentials or other incentives for increasing resource efficiency (see also sections 2 and 3.2). Tab. 4 shows the final research field as a result of the structuring process.

A technology should always be considered within its application context because it can only lead to resource efficient products if the application of the technology is designed in an appropriate way. Technologies, e.g. for extraction of raw materials, process engineering, production engineering (see also section 2.6), can play an important role for the realisation of resource savings when they are applied in research and development, product design and other stages of the lifecycle.

Besides technologies, an approach to resource efficiency potentials through products was selected in this project. Many products are expected to show major resource efficiency potentials mainly due to their raw materials and production processes.

General principles such as lifetime extension, light-weight product design, optimisation solutions from nature (bionics) as well as resource efficient product design have been known for quite a while. However, good implementation examples are rare and the penetration of resource efficiency into practice is still low. Yet, such strategies and principles are a good driver for the increase of resource efficiency because their implementation influences the lifecycles of numerous products. In addition, the integration of product use aspects into technology and product development could lead to completely new solutions for the satisfaction of consumer needs. These product-service-systems (PSS) can create a high innovation potential. For these reasons, relevant methods, instruments and concepts were examined in this project under the term strategies. Management principles (e.g. EMAS), political instruments (e.g. taxes and fees) and qualification concepts were not analysed as they will be reviewed in other MaRess Tasks.

The structure obtained was a guideline for all work stages (see Fig. 7) beginning with the elaboration of the topic list with 1000 proposals, the selection of the “Top250” and the “Top50” and finally the selection of the “Top20”.

Tab. 4: Structure of the field of research

Technologies	Products	Strategies
• Production technologies • Optical technologies • Information and communication technologies • Automation techniques • Environmental technologies • Energy technologies • Nano technologies • Micro-system techniques • Biotechnologies • Material technologies • Building technologies • Other	• Metal products • Plastics • Devices for energy production and distribution • Chemicals • Wooden products • Products for medical, measuring, control and feedback techniques and optics • Paper and cardboard • Construction goods • Secondary raw materials • Textiles • Food • Automotive and other transportation • Electronic devices • Other	• Product use / lifetime extension • Material substitution • Product design • Product-service-systems (PSS) • Life cycle optimisation • Virtualisation • Labelling and marketing • Other

Source: Own Figure

3.4 Technologies, products and strategies for the increase of resource efficiency

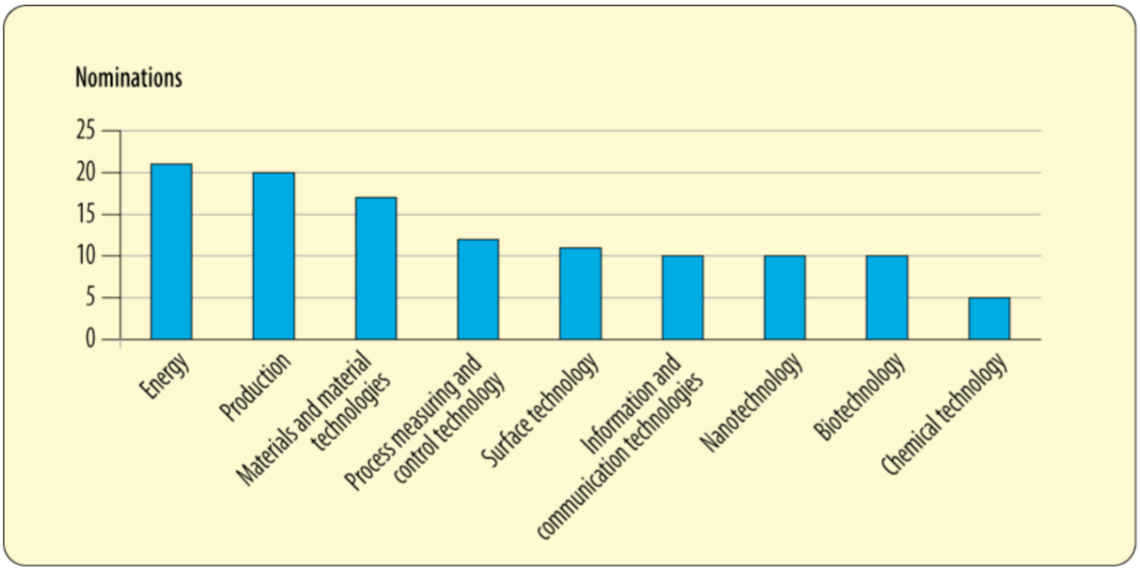
3.4.1 Results of analysis and pre-selection

The desk research and the survey (see section 3.2) resulted in appr. 1000 nominations of single topics, out of which 405 were generated by the survey. 53% of the single topics nominated were technologies, 17% products and 30% strategies. This distribution hardly changed during the next step, resulting in the “Top250” topics (52% technologies, 16% products and 32% strategies).

The distribution of topics within the topic list “Top250” is presented in figures 8 to 10.

The technologies selected show a broad distribution over the fields of technologies presented, with special emphasis on energy technologies, production technologies and materials and material technologies (see Fig. 8).

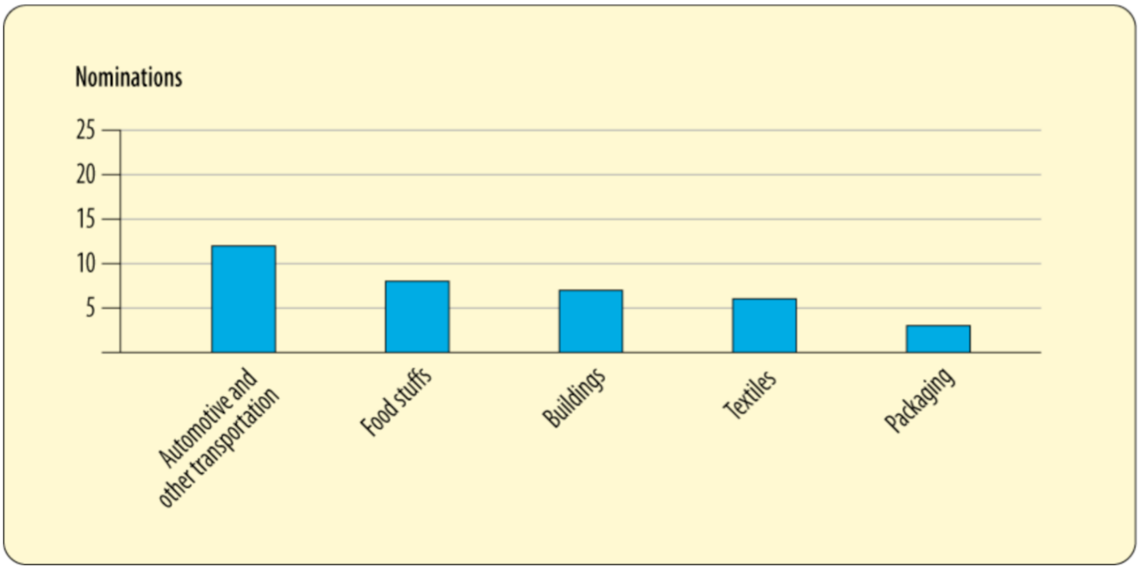
Fig. 8: Nomination of technologies in the "Top 250" topic list



Source: Own Figure

The topic nominations for products reflect the resource intensive demand areas of mobility, nutrition, construction / housing and clothing. Also packaging was nominated (see Fig. 9).

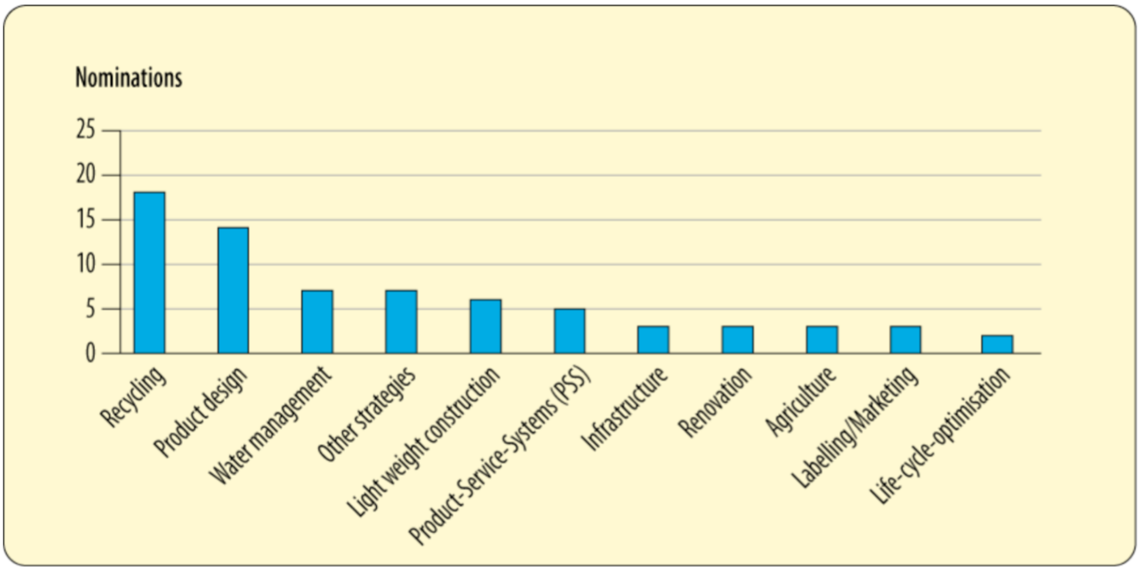
Fig. 9: Nomination of products in the "Top 250" topic list



Source: Own Figure

Strategies show a broad spectrum of differing concepts with recycling and product design clearly dominating (see Fig. 10).

Fig. 10: Nomination of strategies in the “Top 250” topic list



Source: Own Figure

Before the Task 1 expert workshop the “Top250” topic list with 223 single topics was sent to 28 experts. The feedback of almost 80% (22 experts) was included in the evaluated topic list “Top250”. Within the workshop the topic list and the ranking were discussed and validated. Then, a list with around 50 propositions (“Top50”) was deduced and structured. The result is presented in section 3.4.2.

3.4.2 Results of the criteria-based evaluation

On the basis of the differentiated examination as described in section 3.2 and the complex expert-based methods for evaluation with desk research, surveys and expert-workshops (see also chart 7), the topics in tab 5 were ranked as especially relevant. The examples in brackets are results of the expert-based selection process. From these topics, the most relevant ones were selected for a detailed examination of their resource efficiency potential from the beginning of 2009 (see section 4).

Tab. 5: Especially relevant topics in terms of their expected resource efficiency potential

Technologies
• Sensor technologies (e.g. condition monitoring of material & structure, mobile electronic control and feedback control techniques, autonomous distributed micro-systems) • Surface technologies (e.g. refinement and functionalisation with nano technologies, optimisation of tribological systems, new coating technologies: plasma & vacuum techniques) • Process technologies (e.g. vibration cleaning techniques, drying technologies: IR-drying, simulation methods, new transformation technologies for steel, waste-free processes) • Process intensification techniques (e.g. microreactor & processing techniques, new catalysis techniques, combination of conventional process techniques with biological process techniques) • Water management (e.g. membrane technologies for special applications, process water circulation, decentral water management) • Recycling infrastructures and technologies (e.g. recycling of complex products like ships, separation processes for complex material composites) • Material technologies (e.g. material with high functional integration, use of secondary raw materials from earth works, use of material diversity for light weight construction) • Technologies for the use of renewable raw materials (e.g. plants, especially algae, as production platform and raw material supplier, bioplastics) • Technologies for energy supply (e.g. energy-saving technologies & storage mediums, heating & cooling techniques, organic photovoltaic, renewable energies-offshore wind parks)
Products
• Food (e.g. resource efficient nutrition patterns, shortening of process and product chain, decrease waste e.g. by increasing durability, intelligent agriculture: precision farming) • Construction products and infrastructures (e.g. saving mineral materials in earth work, volume and mass reduction through innovative building materials, innovative timber constructions, resource efficient insulation materials) • Mobility and transport (e.g. resource efficient traffic systems, highly efficient electronic cars, light weight construction for vehicles, new drive concepts like SkySails) • Information and communication technologies (e.g. green IT through server virtualisation, thin client and server centric computing, resource efficient broadband optical net technologies and systems, next generation TVs and set top boxes) • Textiles (e.g. substitution of resource intensive fibres, lifetime extension of clothing, technical textiles in light weight construction, textile leasing)
Strategies
• “Design for resource efficiency” (e.g. integration of resource efficiency criteria in design in early stages of product development, bionics) • “Design for Reuse” (e.g. remanufacturing, easier separability of construction connections through shiftable adhesives) • Product Service Systems for the increase of resource efficiency during the use phase of products (e.g. efficiency contracting in chemical industries, new approaches of “using instead of owning” with consumption and investment goods, refurbishing) • New production and consumption patterns for the increase of resource efficiency (e.g. production on demand, self-organisation of production processes, social innovations) • Implementation of resource efficiency in standards (e.g. information tools for design, implement state of the art in technical rules, BAT reference sheets & ISO standards, resource efficiency benchmarking, integrate resource efficiency into eco-design directive, labelling)

Source: Own Figure

3.5 Selecting the "Top20" topics for the estimation of resource efficiency potentials

The final 20 products, technologies and strategies ("Top20" for a detailed potential analysis) were selected in cooperation with the Federal Environment Agency (UBA) and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). They ground on the selection priorities from the expert-workshop as well as external experts and the criteria presented in section 3.4.2. Consequently, all upstream results of the collection and selection process have been included in the "Top20"-list.

The following list includes 24 topics ("Top20"). These topics may be slightly updated according to the availability of case studies and detailed knowledge in the course of the project.

Tab. 6: Selection of the “Top 20 topics“ for the estimation of resource efficiency potentials

Nr.	Topic
1	Resource efficiency potentials through the implementation of light construction beyond use of the diversity of new materials
2	Resource efficiency potentials through use of the micro reactor technique for the production of chemicals
3	Resource efficiency potentials through new transformation technologies for high and highest strength steels
4	Resource efficiency potentials through surface functionalisation with nanotechnologies
5	Resource efficiency potentials through shiftable adhesives for a better separability of construction connections
6	Resource efficiency potentials in production techniques
	Green IT – Resource efficiency potentials in selected fields
7	- Resource efficiency potentials of servers
8	- Resource efficiency potentials of I&C-end-devices
9	- Resource efficiency potentials of telephone and data network
10	Resource efficiency potentials in the clothing industry through fibre substitution
11	Observation of resource efficiency potentials in design
12	Resource efficiency potentials through new approaches of “use instead of possess” in the industrial sector
13	Resource efficiency potentials through production on demand
14	Resource efficiency potentials of the non-energetic use of algae
15	Resource efficiency potentials through new applications of membrane technology for special applications
16	Resource efficient energy production
17	Resource efficient energy storage
18	Resource efficiency potentials of selected value chains of foods
19	Resource efficiency potentials of intelligent agricultural engineering
20	Resource efficiency potentials of insulating materials
21	Resource efficiency potentials in traffic systems
22	Resource efficiency potentials in individual traffic through electric vehicles
23	Resource efficiency potentials through saving of primary mineral construction materials in earth-moving
24	Resource efficiency potentials through separation processes and design possibilities for material composites

Source: Own Figure

4 Summary and conclusions

Procedure in general

The selection of especially relevant technologies, products and strategies for the increase of resource efficiency of is a complex undertaking. This complexity was evident in every single step of the project. A major reason for this is the very broad field of research that had not been limited to distinct products, industries or demand areas beforehand. Additionally, it is hard to find quantitative estimations for resource input and resource efficiency potentials. Therefore, a qualitative expert evaluation was choosen as approach.

The procedure and the methods developed for the identification of relevant topics (as presented in Section 3.4) proofed to be efficient and productive. They were validated in the respective steps by interaction with experts.

Fields of research identified

The fields of research identified (see Tab. 5) and the final “Top20” topics (see Tab. 6) to be analysed deeper on their resource efficiency potential are very broadly distributed regarding the research field in general as well as within the sub-structure of technologies, products and strategies.

Within the technologies almost all established fields as well as new and promising technologies for the increase of resource efficiency are represented. Among the fields of research identified, many technologies are cross-sectional and have broad application fields. The topics rated as relevant are very similar to those that the Forschungszentrum Karlsruhe identified within a parallel project “Roadmap Environmental Technologies 2020” which includes expert estimations for raw material efficient technologies (see e.g. Jörissen et al. 2008).

The products identified reflect very well the resource intensive demand areas in Germany (see Section 2.3). For certain topics there are already existing some preliminary analyses of their resource efficiency. In the next step innovative partial aspects for further analysis will be selected.

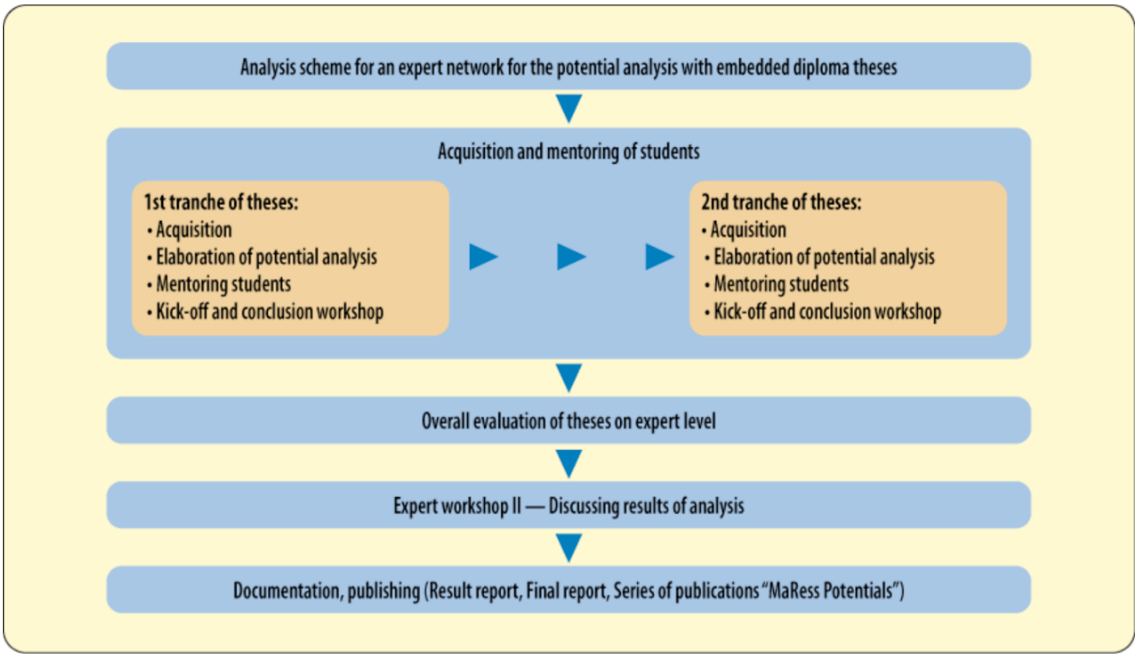
In the broad field of strategies there are several ideas already known but most of them lack an implementation in practice. Further analysis will examine those strategies, the application of which promises high resource savings.

Further action for the potential analysis

From the relevant topics (see Tab. 5) around 20 actual topics (see Tab. 6) have been selected according to the criteria described (see Tab. 3). The resource efficiency potential of these will be analysed.

The rough procedure for the potential analysis beginning in 2009 is presented in chart 11:

Fig. 11: Overview over the procedure of the potential analysis



Source: Own Figure

The core of the potential analysis is a thesis program embedded in an expert network. Each potential analysis will be carried out according to integrative requirements specifying the structure, the methods applied, the evaluation as well as the presentation and discussion of the results. The resource efficiency potentials will be quantified according to the MIPS concept (see Schmidt-Bleek 1994; Ritthoff / Rohn / Liedtke 2002). Besides quantifying the material inputs of the whole lifecycle and potentials for the resource efficiency, measures for action will be discussed in order to show how these potentials could be reached. Intensive expert cooperation (especially from the partner universities) and close cooperation of all participants will guarantee high quality, valid results.

The results will be discussed in several Task 1 - internal workshops and evaluated by related experts. In addition, an expert-workshop will validate the results in spring 2010. In this workshop, the Task 1 partners and further external experts will be involved. A publication series "MaRess Potentials" will document the results of each analysis. They will all be documented in a final report.

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